sPHENIX Magnet Overview

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Brookhaven National Laboratory

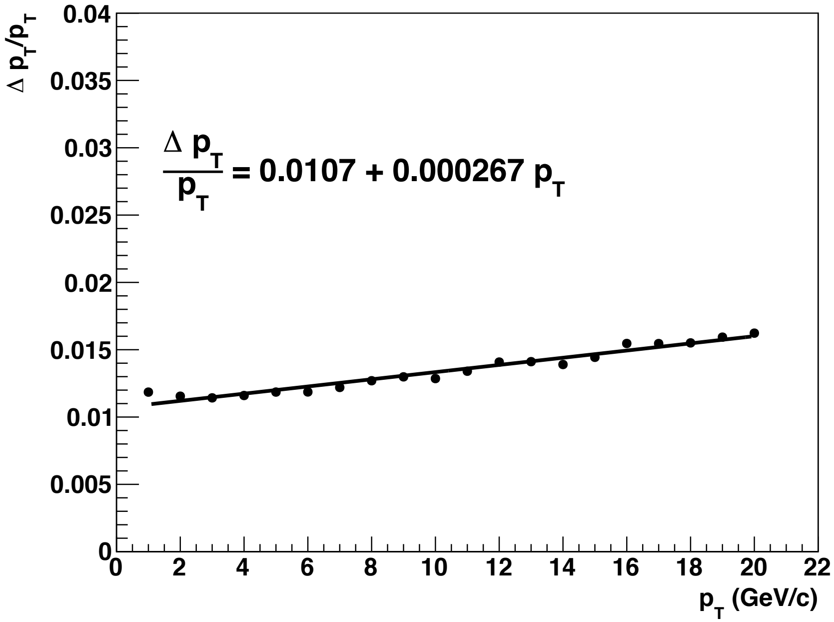
sPHENIX magnet requirements

The complexity of the sPHENIX tracking system has evolved in response to reviews and the scope of physics to be addressed by sPHENIX. The proposal submitted to DOE on November 25, 2014 calls for a tracking system with these specifications:

- $-1 < \eta < 1$ and $0 < \phi < 2\pi$
- Outer radius of tracking volume ≤ 80 cm
- 100 MeV/c^2 mass resolution on ϒ decays
  - Implies p_T resolution ~1.2% for $p_T < 10$ GeV/c

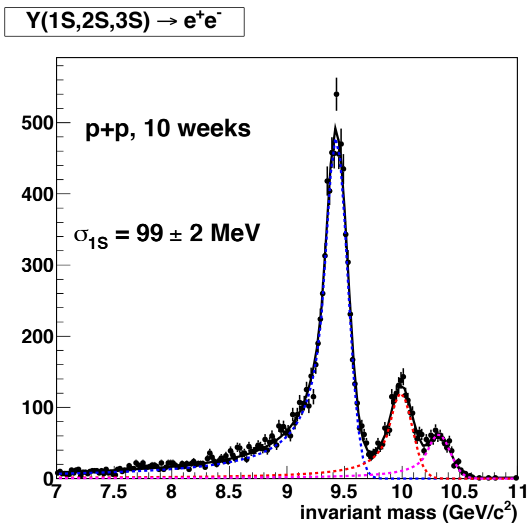
Tracking reference design

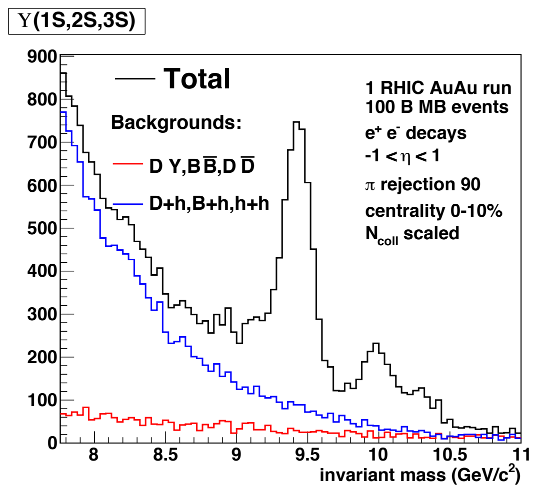
Layer	radius (cm)	sensor pitch (μm)	sensor length (mm)	sensor depth (μm)	total thickness % X_0	area m^2
1	2.7	50	0.425	200	1.3	0.034
2	4.6	50	0.425	200	1.3	0.059
3	9.5	60	8	320	1.35	0.152
4	10.5	240	2	320	1.35	0.185
5	44.5	60	8	320	1	3.3
6	45.5	240	2	320	1	3.5
7	80.0	60	8	320	2	10.8

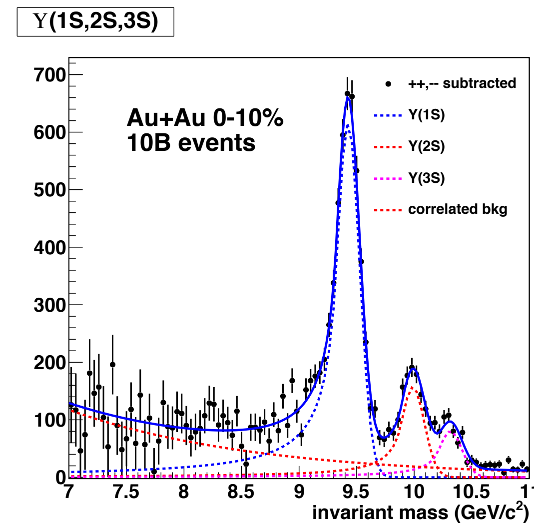


See current sPHENIX proposal:
http://www.phenix.bnl.gov/phenix/WWW/publish/documents/sPHENIX_proposal_19112014.pdf

Upsilons in p+p and Au+Au







The BaBar magnet is ideal for sPHENIX

The BaBar magnet is not a compromise for sPHENIX—it is pretty much the ideal magnet for jet and upsilon physics at RHIC:

- Solid angle coverage matches jet production
- Field strength allows momentum resolution goals to be achieved inside electromagnetic calorimeter
- Electromagnetic calorimeter can fit inside which keeps the size and cost low and minimizes material in front

Basic solenoid parameters

- Central field: 1.5 T
- Operating current: ~4600A
- Cryostat dimensions (mean coil radius 152 cm)
  - Inner radius 140 cm
  - Outer radius 178 cm
  - Length 385 cm
- Material thickness at normal incidence ~0.3 λ_I
- Ramp to full field ~35 min in BaBar

Evolution of sPHENIX magnet concept

- October, 2012 BNL Review of sPHENIX
  - Called for new thin 2T solenoid 70 cm inner radius
  - Scaling of other solenoids and a budgetary quote from Ansaldo gave us an estimated cost of $5.5M
  - "Recent commercial procurements of superconducting magnets such as the proposed solenoid have proved problematic."
- December, 2012 SuperB canceled
- May 27, 2013 I visit magnet at SLAC and begin arrangements to bring it to BNL
- July 18, 2013 DOE approves transfer to BNL

STANDARD FORM 122
JUNE 1974
GENERAL SERVICES ADMINISTRATION
FPMR (41 CFR) 101-32.306
FPMR (41 CFR) 101-43.315

TRANSFER ORDER
EXCESS PERSONAL PROPERTY

1. ORDER NO.
SLAC 2013-07-18

2. DATE
July 18, 2013

3. TO: GENERAL SERVICES ADMINISTRATION*

4. ORDERING AGENCY (Full name and address)*
Brookhaven National Lab
Attention: John Haggerty; haggerty@bnl.gov
Upton, NY 11973-5000

5. HOLDING AGENCY (Name and address)*
SLAC National Accelerator Laboratory
2575 Sand Hill Road, MS 85A
Menlo Park, CA 94025

6. SHIP TO (Consignee and destination)*
Same as block 4

7. LOCATION OF PROPERTY
SLAC National Accelerator Laboratory
C/O Mike Racine
2575 Sand Hill Road, MS 53
Menlo Park, CA 94025
650 926-3543 racine@slac.stanford.edu

8. SHIPPING INSTRUCTIONS
BNL to arrange for shipping

9. ORDERING AGENCY APPROVAL
A. SIGNATURE
B. DATE 7-19-13
C. TITLE Property Manager

10. APPROPRIATION SYMBOL AND TITLE
transfer from DE-AC02-76SFO0515
transfer to DE-AC02-98CH10886

11. ALLOTMENT

12. GOVERNMENT B/L NO.

13. PROPERTY ORDERED

GSA AND HOLDING AGENCY NOS. (a)	ITEM NO. (b)	DESCRIPTION (Include noun name, FSC Group and Class, Condition Code and if available, National Stock Number) (c)	UNIT (d)	QUANTITY (e)	ACQUISITION COST UNIT (f)	ACQUISITION COST TOTAL (g)
		Administrative Transfer				
	1	BaBar Solenoid and Components Date of Mfr: 1996 (See attached list)	ea	1	12,000,000.00	$ 12,000,000.00
					Total Acquisition Cost	$ 12,000,000.00

Export Restriction Notice

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(b) Any use or disposition, export or re-export of the property which is not authorized in accordance with the provisions of this agreement.

14.	A. SIGNATURE	B. TITLE	C. DATE
GSA APPROVAL			
SLAC APPROVAL		Property Manager	7/18/2013

FOR GSA USE ONLY	AGENCY AND LOCATION: AGENCY	STATE			FSC	CONDITION	SOURCE CODE

*Include ZIP Code

122-112

BNL property

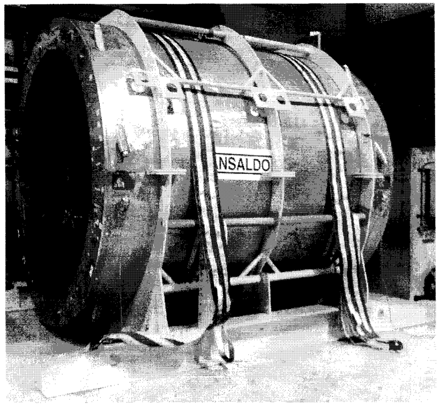
☐ Scan Link ☐ Scan Archive ☐ Copy to Area

SLAC Radiation Protection Dept. Radiological Survey Form	DATE: 14 March 2011

[X] SURFACE CONTAMINATION	[X] RADIATION SURVEY	AREA / ITEM SURVEYED: BaBar Solenoid

Legend: γ / (η) — Radiation Survey Points (expressed in mR/hr γ mrem/hr η) — Radiation Area Boundary - - - - — High Radiation Area Boundary -x-x-x-x-x-x — Contamination survey point (see table for results) ① — Contamination Area: ////////// — Item/Area direct frisked ######## — Operating Condition(s): BaBar D&D from IR-2

- BaBar bar code s/n: 20006120



Radiation Survey Instrument

Instrument model			Detector model			Inst. S/N	Cal Due	Detector S/N.	Radiation Type
☐ Ino 451P	☐ HPI 5085	☐ Bic μrem	[X] 44-2 (Ludlum)	☐ 270	1	261350	5/8/11	229264	[X] β/γ ☐ photon ☐ η
☐ Vic 450P	☐ Eb ASP-1	☐ Bic mrem	☐ FHZ-612 (tele)	☐ 290	2	N/A			☐ β/γ ☐ photon ☐ η
☐ Vic 450B	☐ Eb ASP-2e	☐ Lud 18	☐ Other: ____	☐ NRD					
☐ Ino 451P	☐ Eb FH-40	[X] Lud 2241-2							
		☐ Other ____							

Contamination Survey Instrument

Eberline	Tech Assoc.	Ludlum	Detector model			Avg. Bkgd (CPM)	Eff %	Inst. S/N	Cal Due	Detector S/N.	Contamination Type
☐ RM-25	☐ TBM-3	[X] 2241-2	☐ TBM/P-15	☐ HP 210T	1	30	10	261350	5/8/11	197113	[X] β/γ ☐ α
☐ RM14-SA	☐ TBM-15	☐ 2929	[X] 44-9	☐ HP-360	2	N/A					☐ β/γ ☐ α
☐ Other ____		☐ 3030	☐ 43-92	☐ 44-2							
			☐ Other ____								

Survey Point	Net cpm/100 cm²	Net dpm/100 cm²	Location	Survey Point	Net cpm/100 cm²	Net dpm/100 cm²	Location
1				6			
2		N/A		7		N/A	
3				8			
4				9			
5				10			

[X] Radiation [X] Contamination Survey (cont.)

REMARKS

- Survey performed per SLAC-I-760-2A05C-016 (BaBar Radiological Survey Procedure) and SLAC-I-760-2A30C-006 (RP Dept-Criteria Defining and Monitoring for Radioactive Material), on all accessible surfaces, no radioactivity detected.
-
-

Location in IR-2 item originated: **BaBar detector**

[X] Item **IS** Subject to DoE Suspension (i.e. ' HOLD') ☐ Item **NOT** Subject to DoE Suspension (i.e. ' HOLD')

This area/item contains/or posted as: NOTE: Check each box as applicable

☐ Radiation Area	☐ Radiation Hot Spots	☐ Personnel Exclusion Area
☐ High Radiation Area	☐ Contamination Area	[X] Other Controlled Area

1. OPERATIONAL CHECKS, SOURCE CHECKS & CALIBRATION REQUIREMENTS HAVE BEEN MET ON ALL INSTRUMENTS USED FOR THIS SURVEY.
2. CONTAMINATION SURVEY DATA IS FOR LOOSE SURFACE CONTAMINATION UNLESS OTHERWISE STATED.
3. RECORD dpm AS <MDA IF NET CPM IS <100 CPM ABOVE BACKGROUND.
4. # INDICATES AREA/ITEM SURVEYED WITHIN 1/2" USING EITHER A PANCAKE GM TUBE OR EQUIVALENT FOR β/γ, NaI (sodium iodide) DETECTOR, FOR PHOTONS, AND ZnS (zinc sulfide) DETECTOR WITHIN 1/4" FOR α. ' NO DETECTABLE ACTIVITY.'

AREA/BLDG.: IR-2	DATE: 14 Mar 2011	TIME: 1500

REASON

☐ ROUTINE	☐ Bi-WEEKLY	☐ WEEKLY	X JOB SPECIFIC SURVEY (EXPLAIN IN REMARKS)
☐ R.O.D. RELATED	THE PERSON DESIGNATED FOR AN ACTION VERIFIES, BASED ON PERSONAL OBSERVATION & CERTIFIES BY SIGNATURE, THAT THE ACTION HAS ACTUALLY BEEN PERFORMED IN ACCORDANCE WITH THE SPECIFIED REQUIREMENTS.		
☐ SHIPPING/REC'V			

SURVEYED BY (PRINT NAME): Ray Russ	SIGNATURE:	DATE: 14 March 2011
THIS DOCUMENT HAS BEEN REVIEWED IN ITS ENTIRETY FOR COMPLETENESS AND FOUND TO BE SATISFACTORY.	SUPERVISORS SIGNATURE:	DATE: 14 MAR 2011

Radiologically safe

Solenoid in End Station A

May 27, 2013

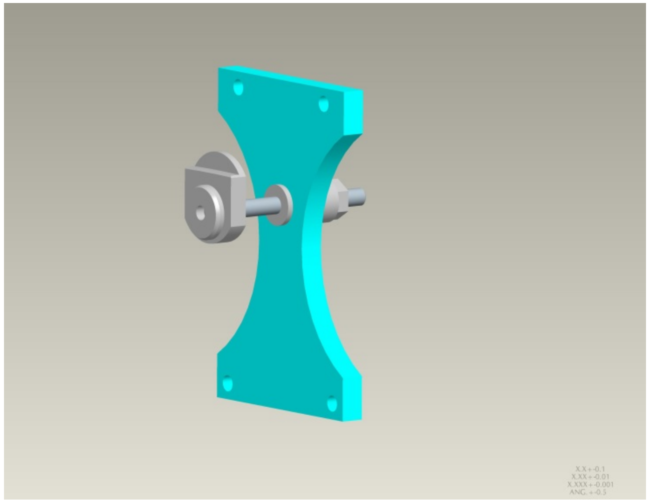
Preparation for transport

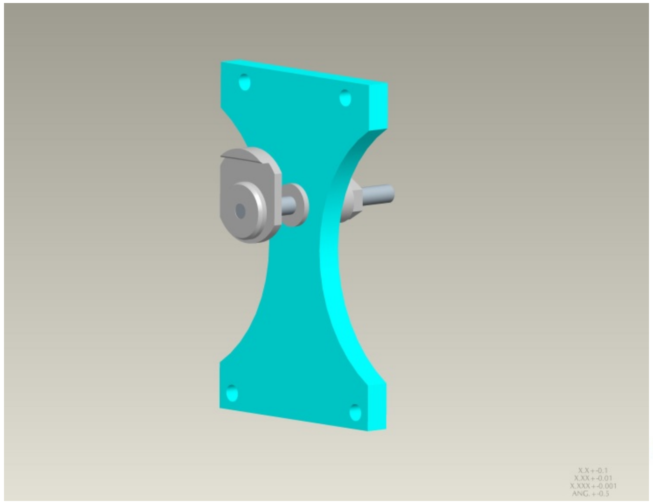
- Since July 2013, Mike Anerella and Paul Kovach in the Superconducting Magnet Division have been preparing to transport the magnet to BNL and set up a low power test
- After studying the solenoid design and consulting one of the original key designers (Pasquale Fabbricatore, INFN), Paul designed some transport restraints for the thermal shield
- Review (Craddock and Racine, SLAC, and Fabbricatore, INFN) on July 30, 2014 identified another issue with the valve box for which Paul designed a solution

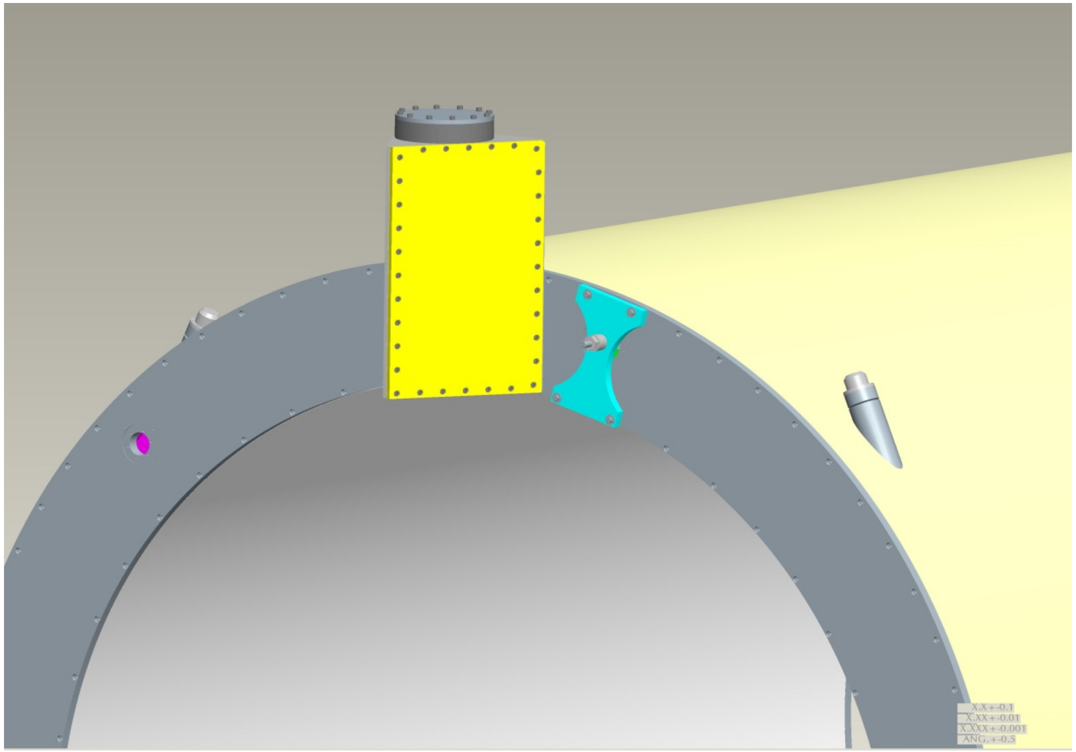
Transport options

- We considered several possible ways to transport the coil to BNL, but truck involves the least handling and allows SLAC and BNL riggers to do all loading and unloading
- Several quotes and bids in the past year from truckers who have worked on DOE projects
- The order is placed and tentatively scheduled for shipment during the week of January 12, 2015

Heat Shield Shipping Restraints







Shipment by Cast aborted November 10, 2014
New RFQ resulted in PO placed December 12

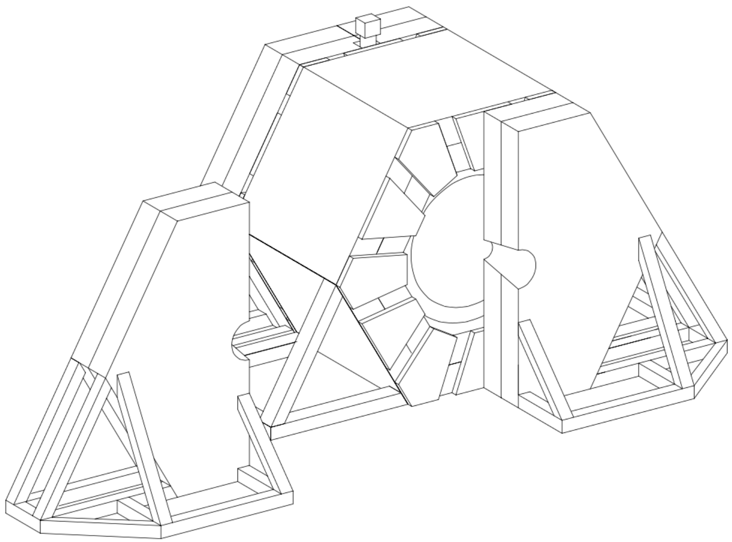
Other equipment

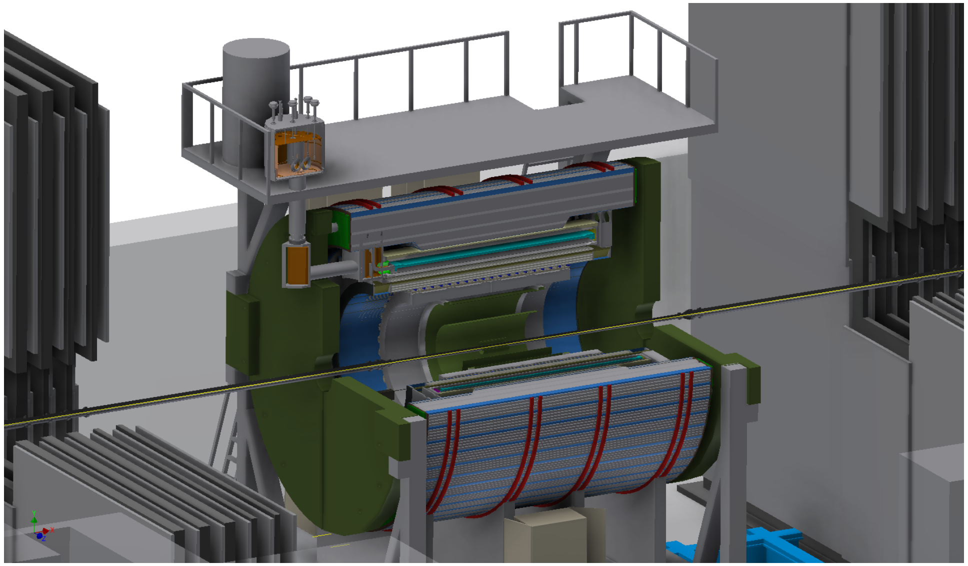
In addition to the solenoid itself, we are getting a considerable amount of other equipment from SLAC:

- Valve box and transfer line
- Power supply (and a spare)
- Dump resistor
- Quench protection electronics
- Lifting fixtures

Flux return

- The sPHENIX outer Hadronic Calorimeter has been designed to do double duty as the flux return for the solenoid as well as a crucial calorimeter system
  - Central flux 1.5T through 152 cm radius ~10.8 T-m^2
  - 2T saturation through steel 195 < r < 260 cm ~ 18.4 T-m^2
- Confirmation and optimization with 2D Opera calculations by Achim Franz
- Solid state photodetectors insensitive to magnetic field don't require careful trimming of field (BaBar had thousands of PMT's which required them to be extremely careful about the fringe field)



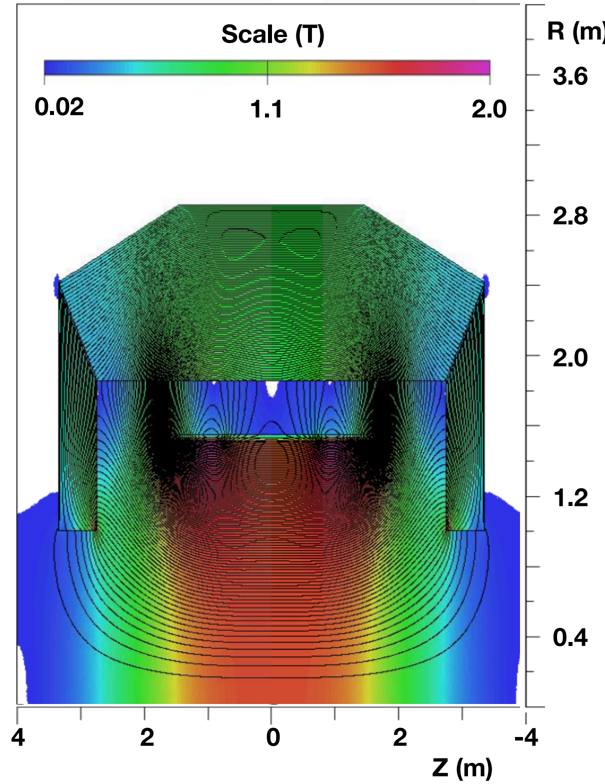


BaBar flux return (TDR)

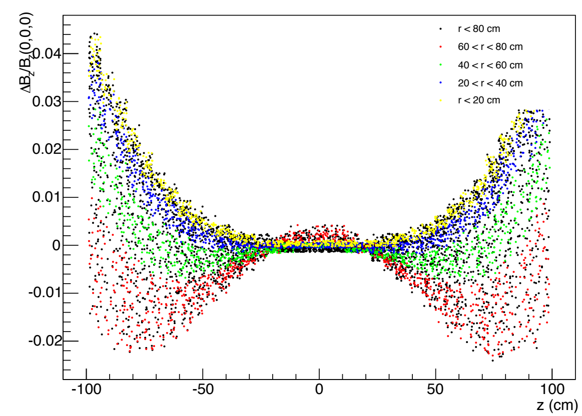
Conceptual design of sPHENIX HCAL as flux return

Field maps

- Achim Franz has calculated (2D) field maps for a number of situations
- Field maps have been imported into silicon tracking simulation, alternative tracking would need further analysis
- The effect of the fringe field on magnetics in the electronics and access to the IR with the field on drove us to clamp the field, but we're thinking about our options

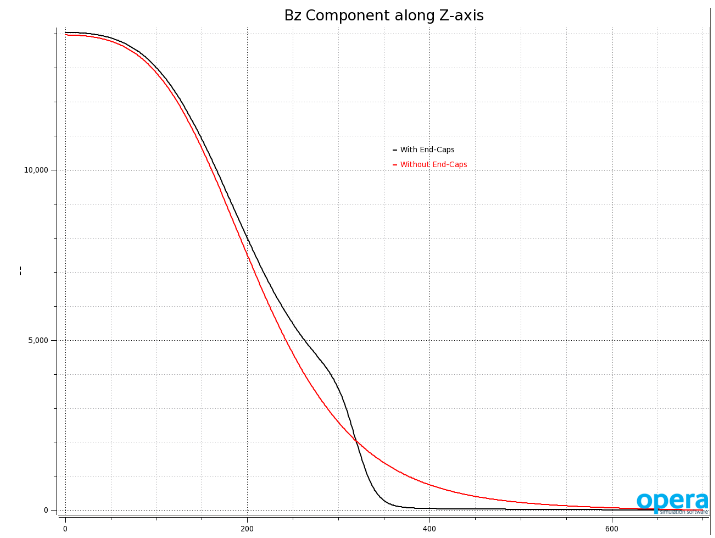


sPHENIX central 1.54 T magnetic field



3D Opera

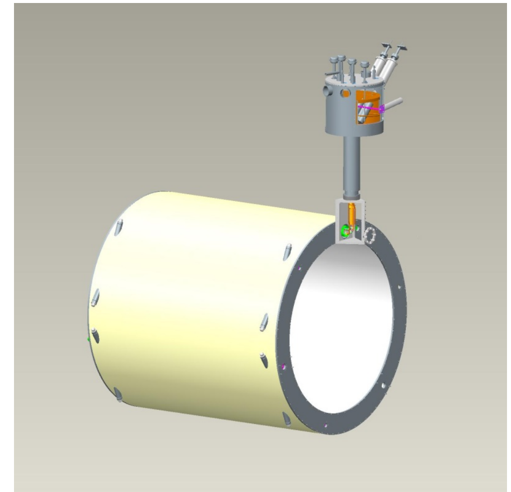
- Wuzheng Meng has just begun helping us with 3D magnetic field and force calculations
- We'll need some iterations to study the ramifications and our options

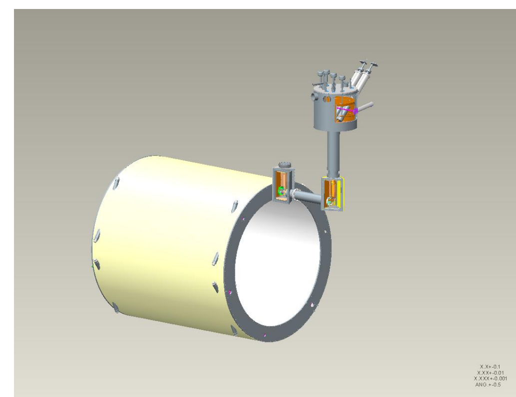


1 kG just outside without endcaps

Chimney modification

- In order to keep the acceptance of the hadronic calorimeter as uniform as possible, we would like to avoid a penetration for the chimney leading to the valve box
- Working from drawings, Paul Kovach has designed a rather non-invasive way to do this that he will describe





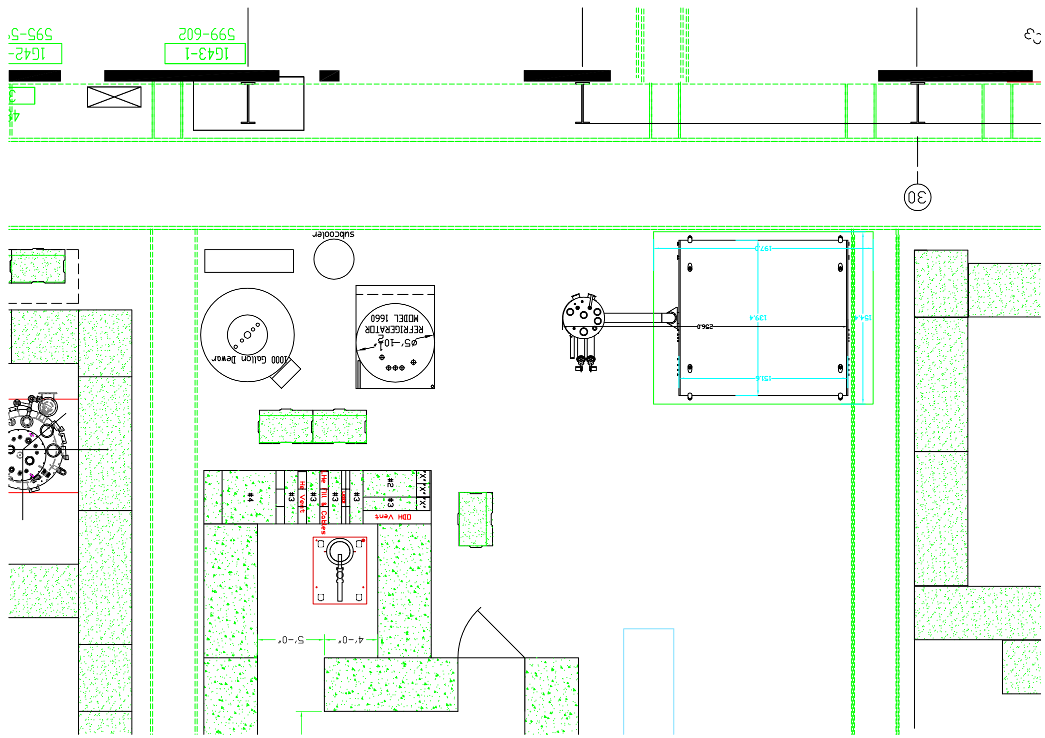
Before and after

The next steps

You will hear more details about a low power test that we are planning for the first half of 2015 in Building 912 in the next few talks

- Setting up the magnet test facility
- Cryogenics
- Power supply and controls
- Instrumentation

Test area in building 912

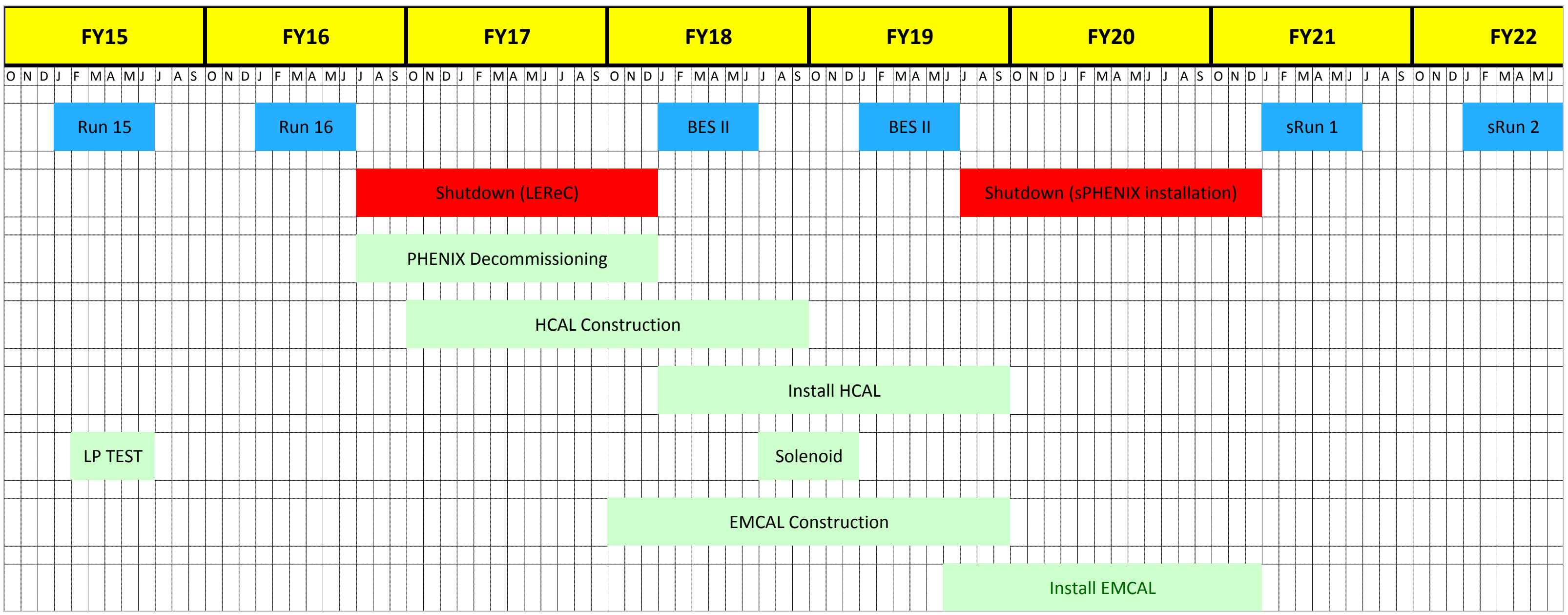


Test area designed by Dave Phillips

Further down the road

- Plans for installing the magnet in its flux return
- We are considering how early we could do a close to full power test or whether we could do a higher power test without building the entire outer HCAL
- Studies are under way in simulation, analysis, and design on the stresses on the solenoid and structure

sPHENIX schedule



Summary

- The BaBar magnet provides an excellent foundation for the sPHENIX experiment and beyond
- Initial steps to bring the magnet to BNL and determine its basic health are under way
- Design and optimization of the whole detector incorporating the magnet are under way